SNS ACCUMULATOR INJECTION

H– Transport and Injection Mini-Workshop

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ACKNOWLEGEMENT

- BNL SNS ACCELERATOR PHYSICS TEAM
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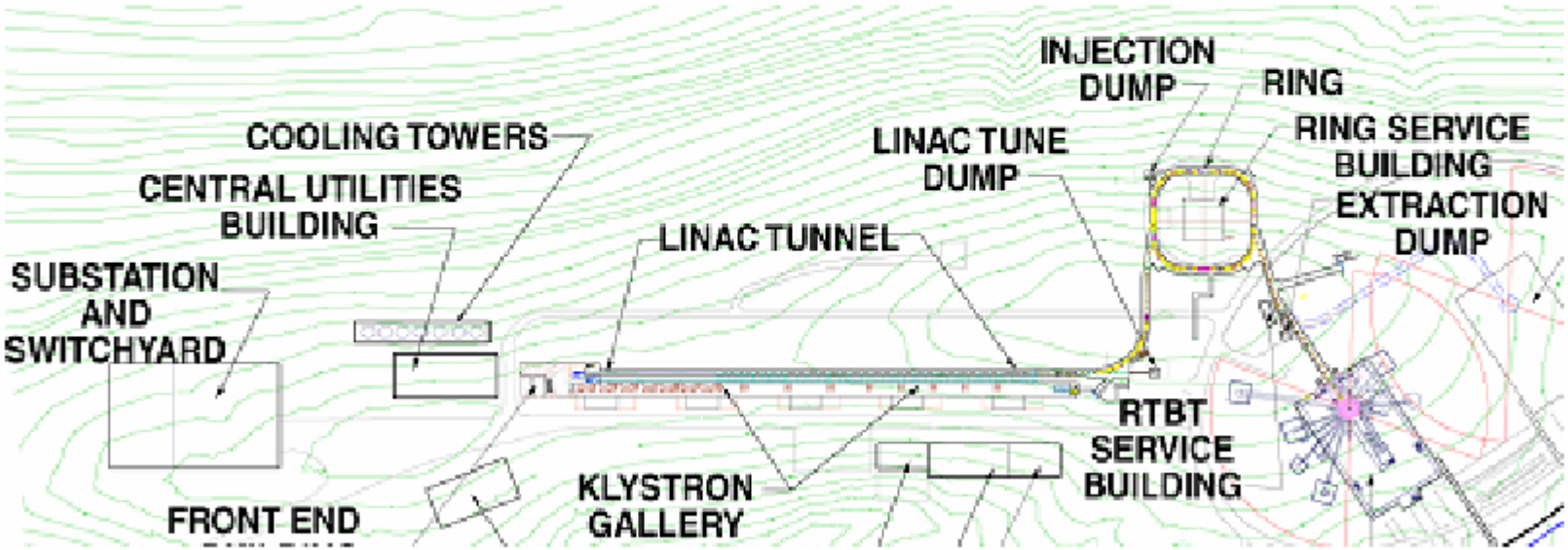
SNS LAYOUT

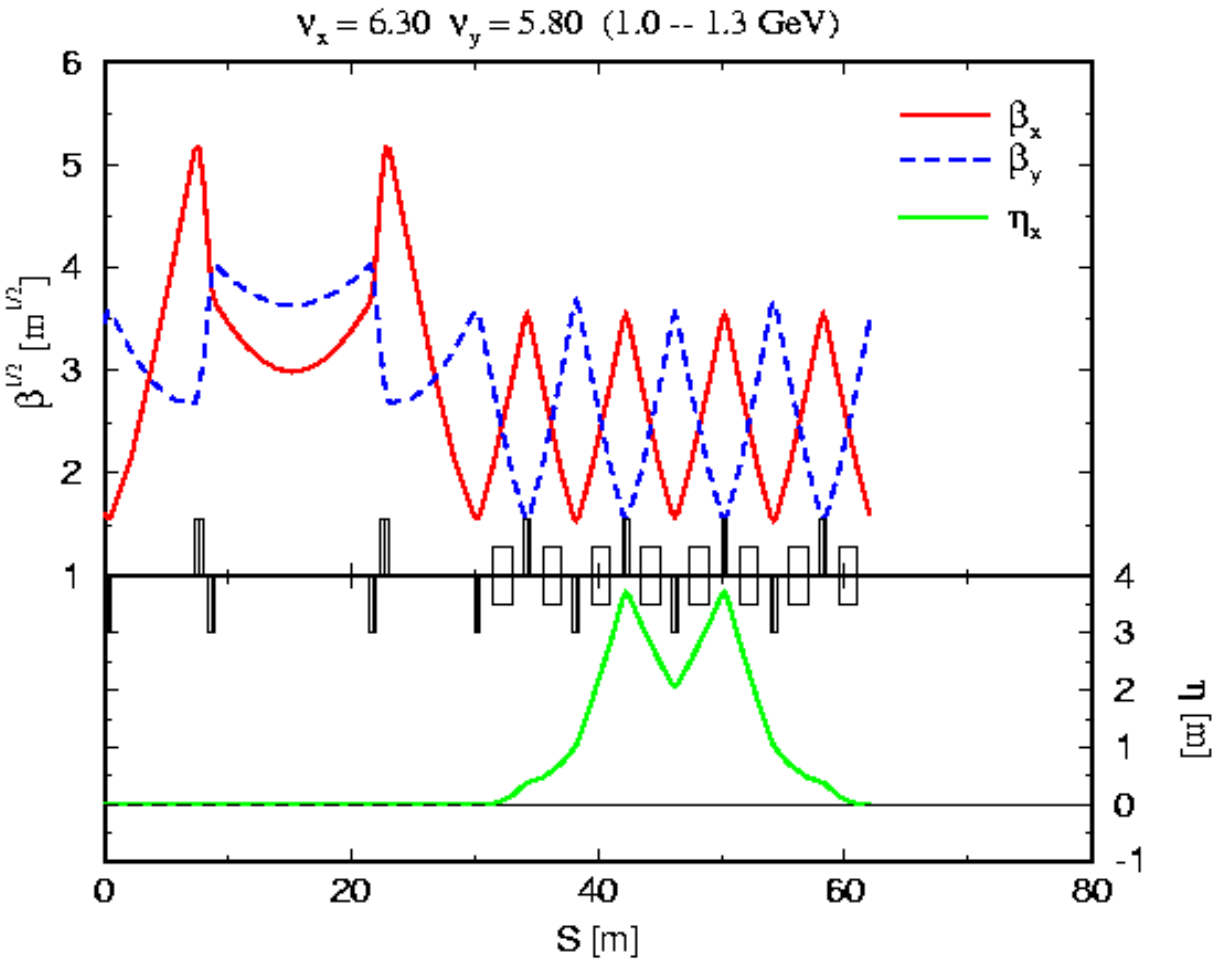
- Extra long linac tunnel is reserved for future energy/power upgrade; ring capacity reserved



ISSUES

- VERY HIGH PROTON POWER
- UNPRECEDENTED NUMBER OF PROTON ACCUMULATION 2 X 10^{14}
  - SPACE CHARGE
  - LOSS AND COLLIMATION
  - INSTABILITIES AND IMPEDANCE
- HANDS ON MAINTENANCE
  - LIMIT LOSS TO < 1 WATT / m (10^{-4} LOSS)
- STRICT PROTON DISTRIBUTION REQUIREMENTS AT THE TARGET
  - INJECTION PAINTING
- RELIABILITY, AVAILABILITY AND MAINTAINABILITY

RING LATTICE FUNCTIONS



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SNS SPALLATION NEUTRON SOURCE

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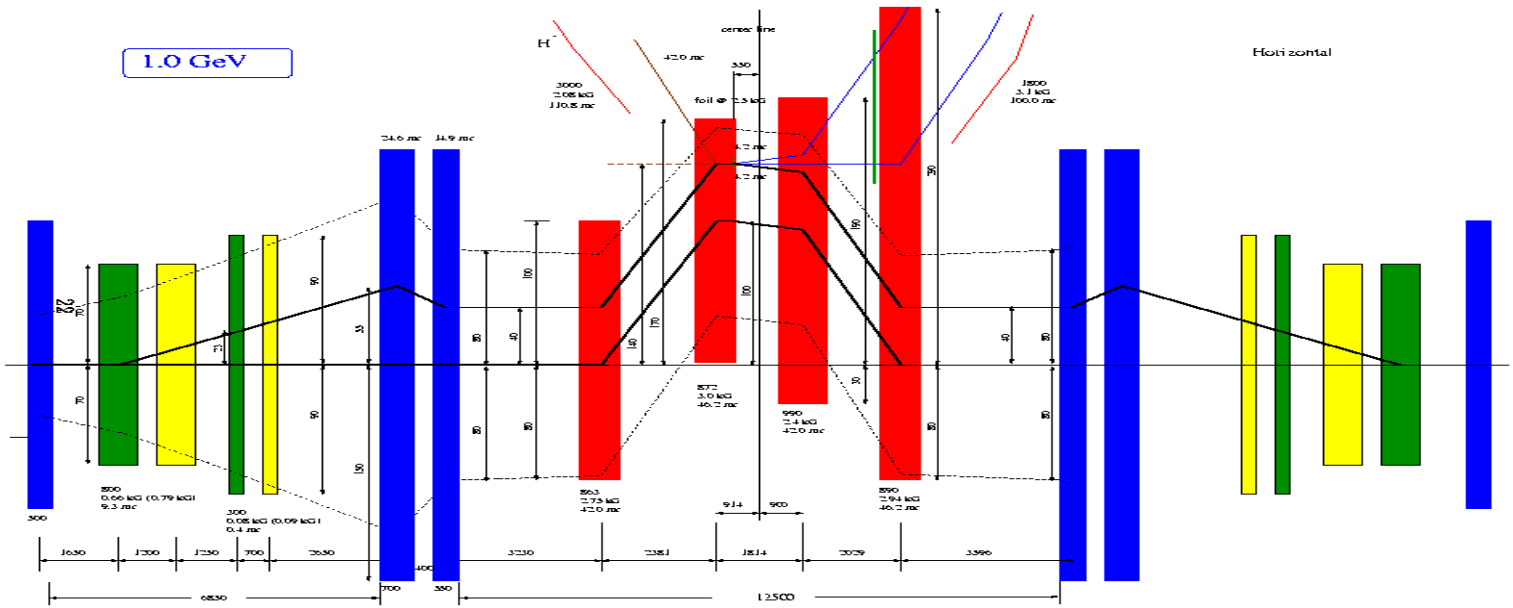
Injection layout

Fixed chicane

Dynamic bump

Dynamic bump



INJECTION LOSSES and STRIPPING FOIL

- EXCITED STATE H^O EMERGING FROM FOIL
  - 2 ~ 10 % DEPENDING ON FOIL THICKNESS
- SINGLE AND MULTIPLE SCATTERING
- NUCLEAR SCATTERING
  - DEPENDS ON FOIL THICKNESS AND SIZE (EFFECTIVE LINAC EMITTANCE)
- LINAC BEAM MISSING THE FOIL
  - STABILITY OF LINAC BEAM
  - CONTROLLED DUMPING TO INJECTION DUMP
- ISSUE OF TWO STRIPPED ELECTRON DUMPING (~2 KW)
  - COLLECTION OF TWO STRIPPED ELECTRONS
  - FOIL HEATING AND LIFE

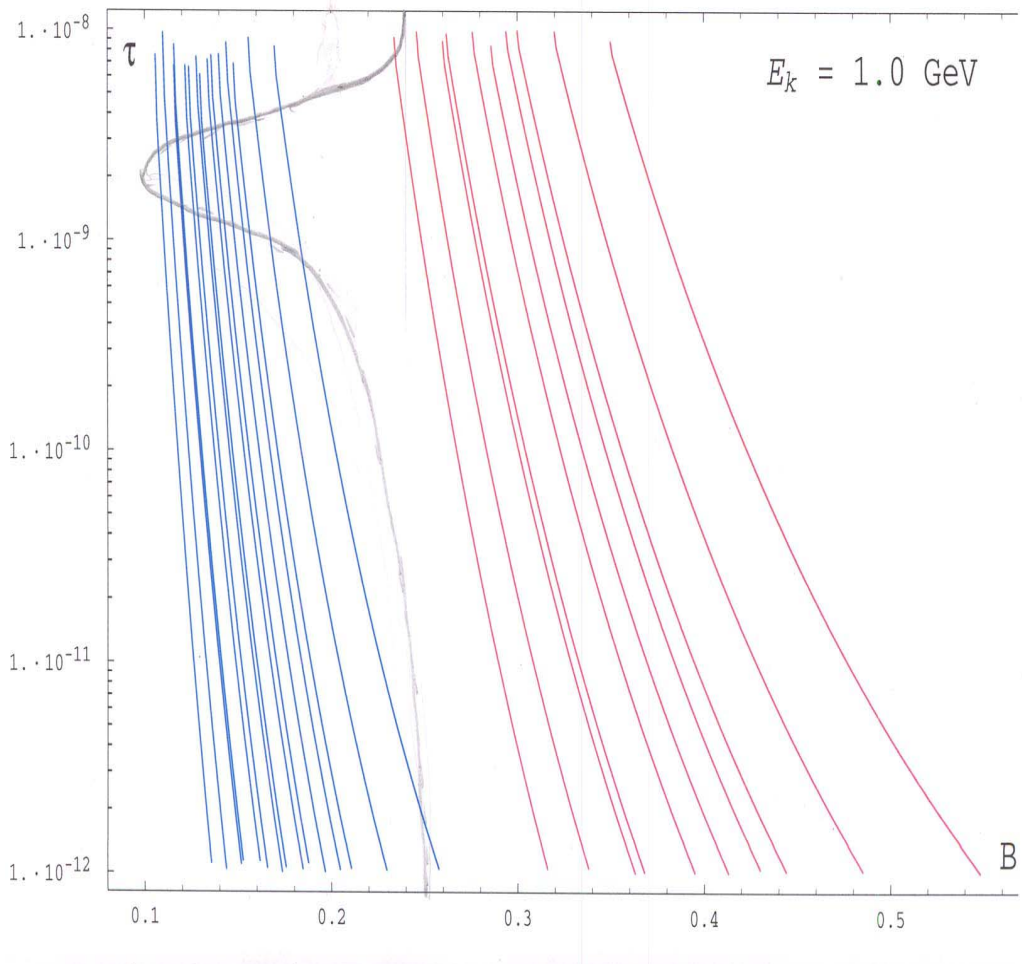
H^- STRIPPING FOIL ISSUES

- REQUIRED HIGH INTENSITY LOW EMITTANCE LINAC BEAM
- HEAT LOSS MECHANISM
  - BLACKBODY RADIATION
  - CONDUCTION
- THERMAL SHOCK OF RAPID HEATING AND COOLING
- HEATING---VOLUME EFFECT
- COOLING---SURFACE
  - THE THINER SURVIVES LONGER

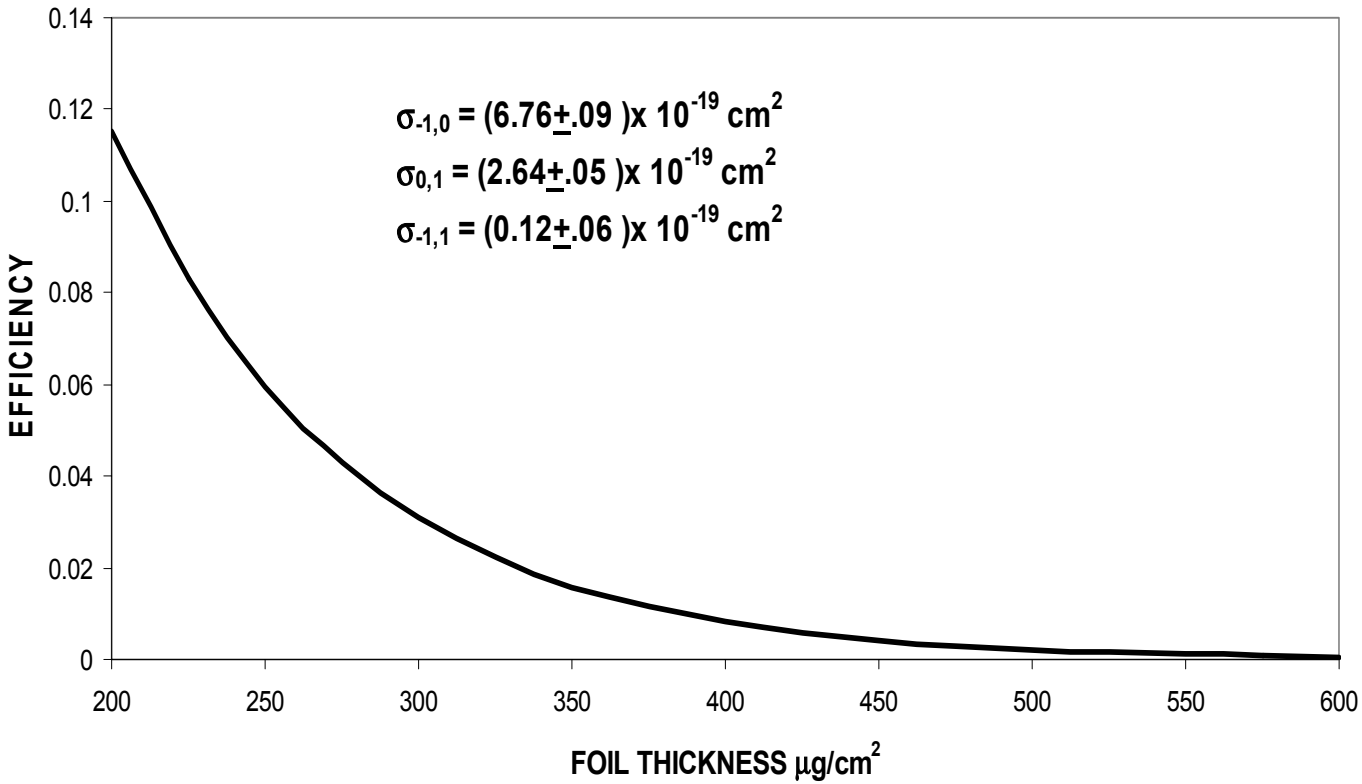
EXCITED H^O LIFETIME

LIFE TIME vs MAGNETIC FIELD FOR n=4 and 5 STATE

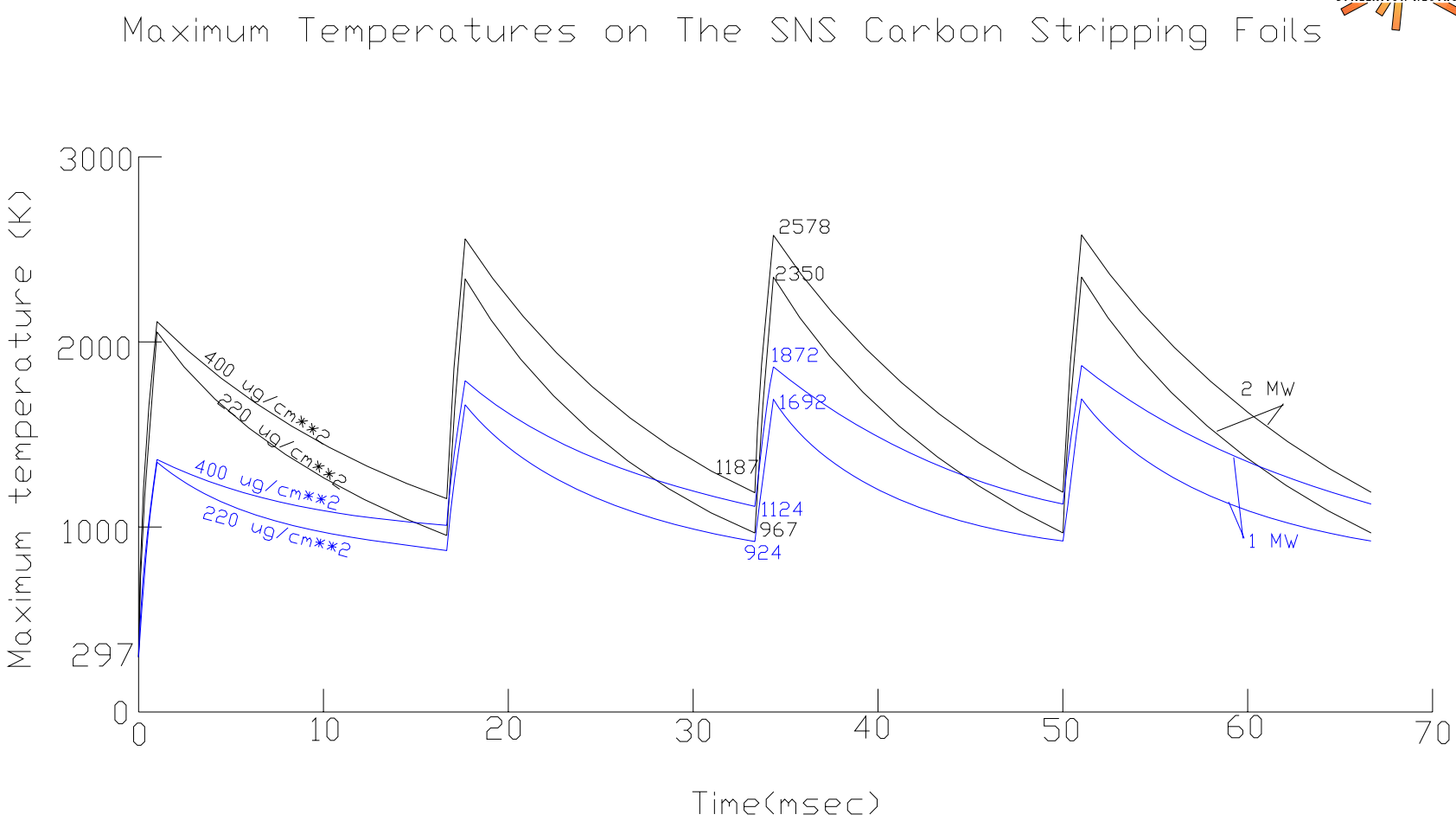
10^{-5} OF INJECTED BEAM IS EXPECTED OUTSIDE $\varepsilon=160\pi$ mm-mr



STRIPPING EFFICIENCY @ 1 GeV



CALCULATED FOIL TEMPERATURE



Design Requirement of #2 and #3 Chicane Magnets

#2 --- Bo=3.0 kG

B (foil) = 2.5 kG > B(bottom); $\tan^{-1}(Bz/By)$ >>65 mrd

Gap = 23.5 cm (8.750 inch)

#3 --- Bo = 2.4 kG (must smaller than 2.5 kG)

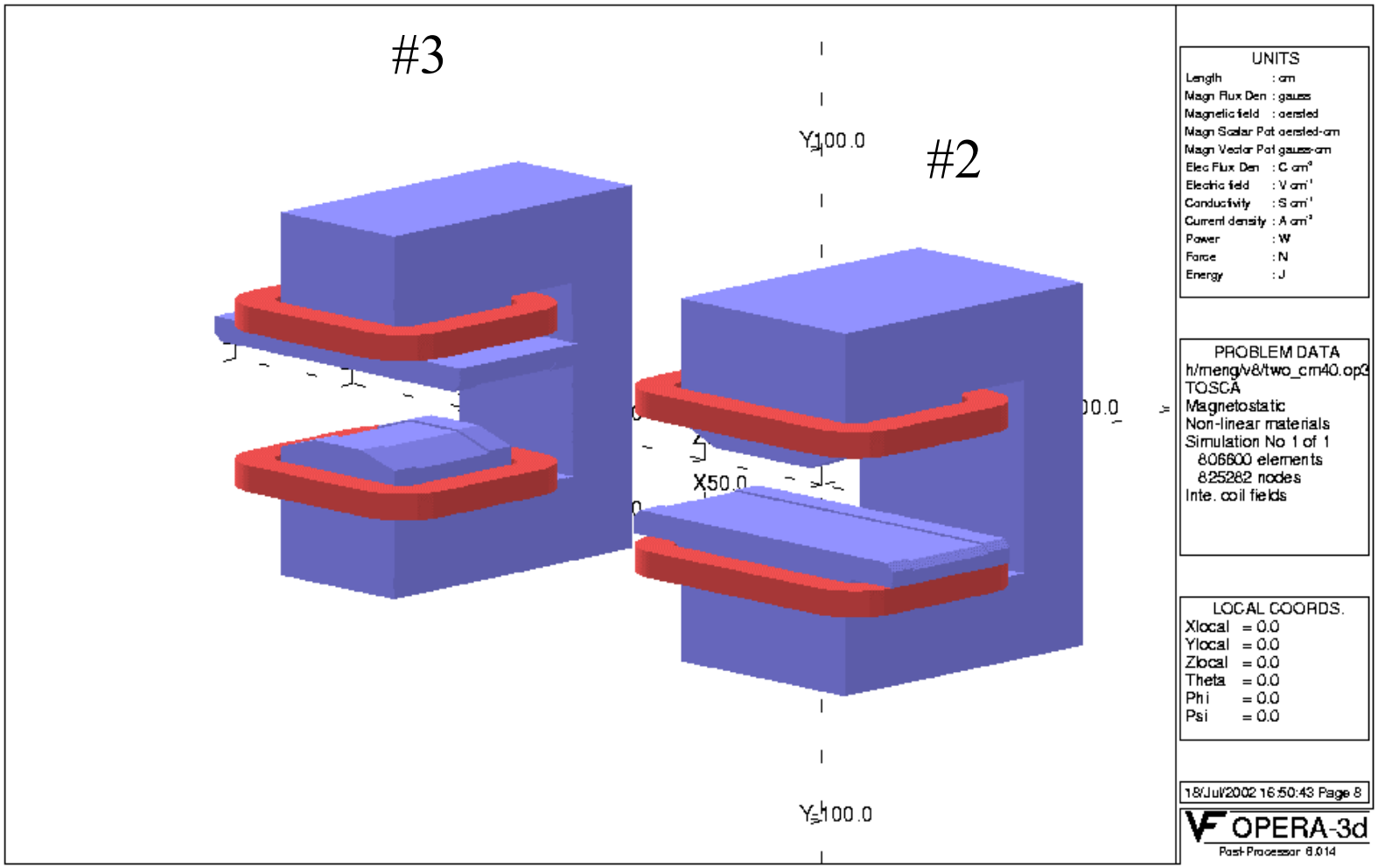
Distance (center to center) = 181.4 cm (71.42 inch)

Field Integrals from $-\infty$ to foil = 237.6 kG-cm

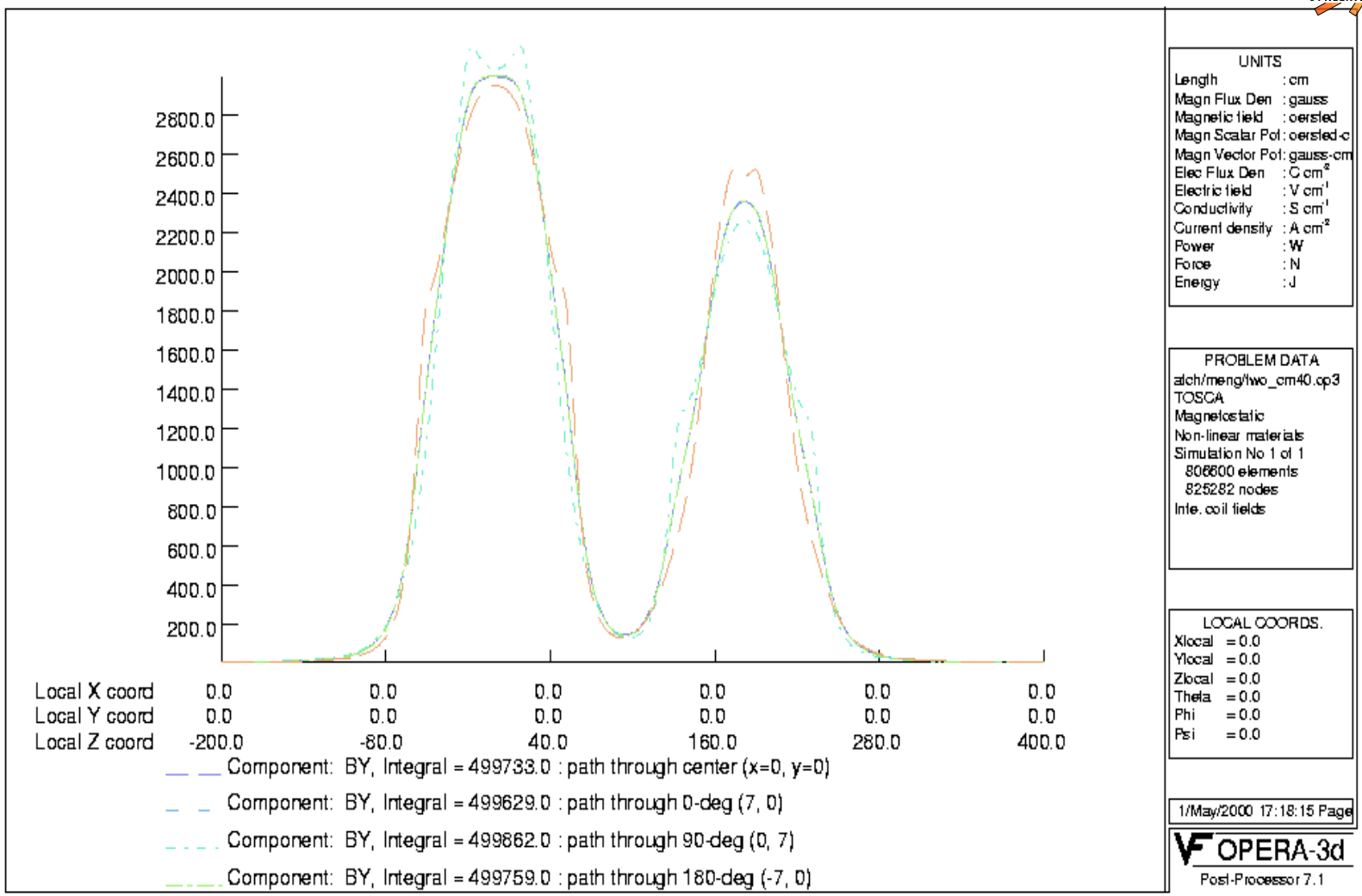
from foil to $+\infty$ = 261.4 kG-cm

two C magnets = 499 kG-cm, to 0.5e-4 (R=7cm)

#2 and #3 C magnets (with coils)



- Total Integral along 0, 90, 180, 270 degree lines

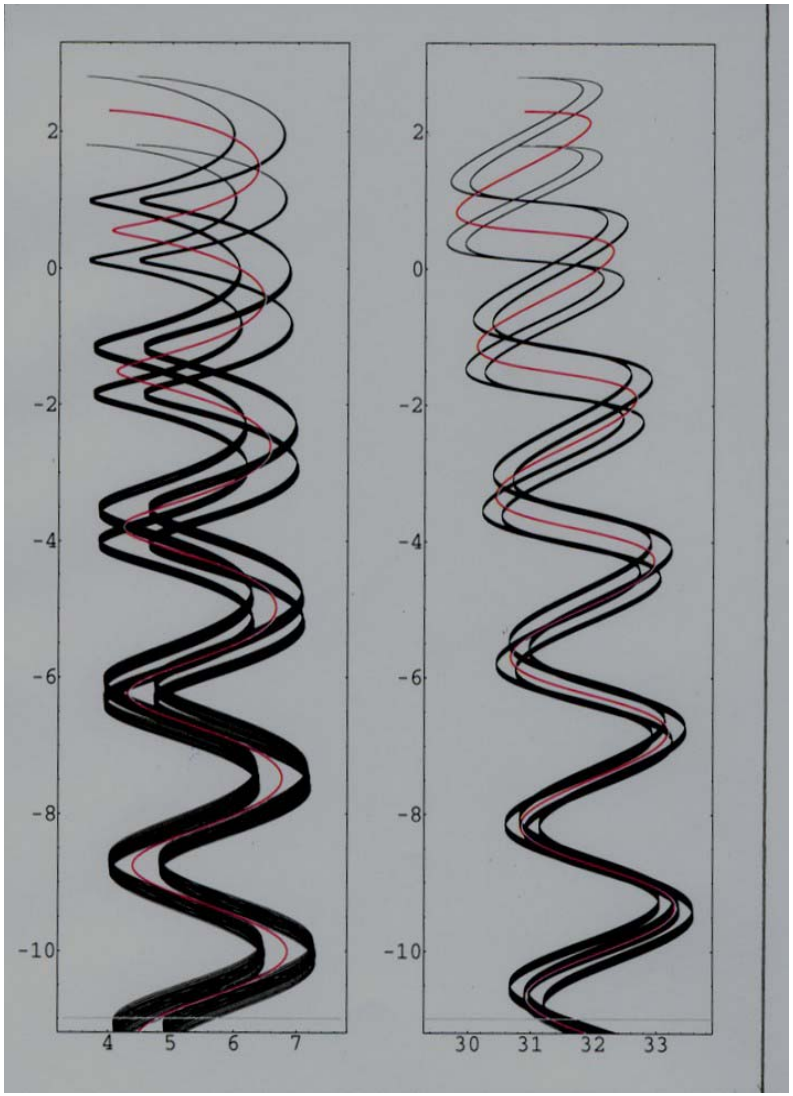


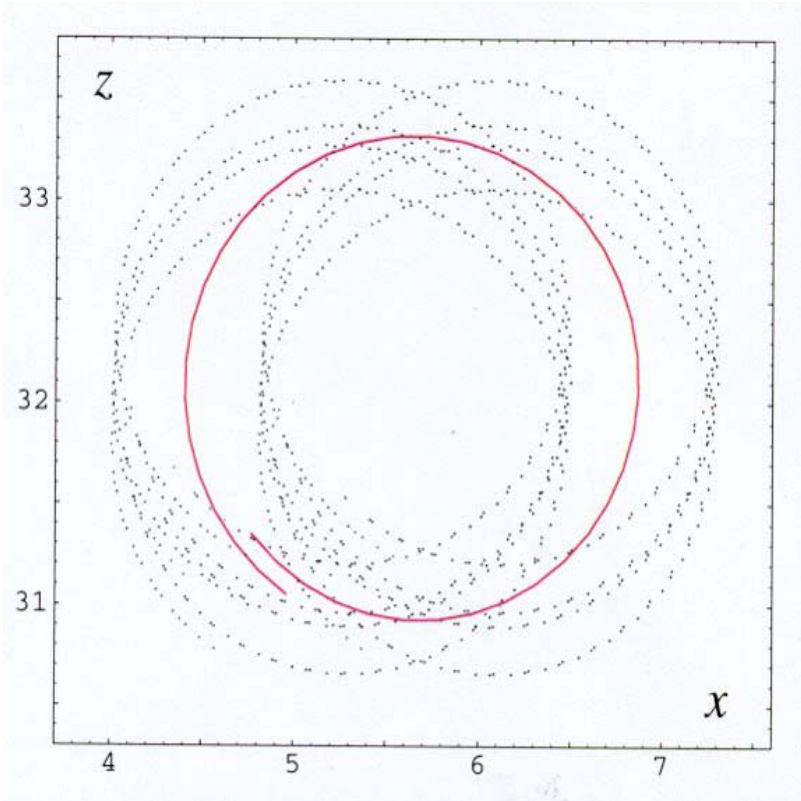
Integrated Multipoles

(R=8 cm; z from –200 to 400 cm)

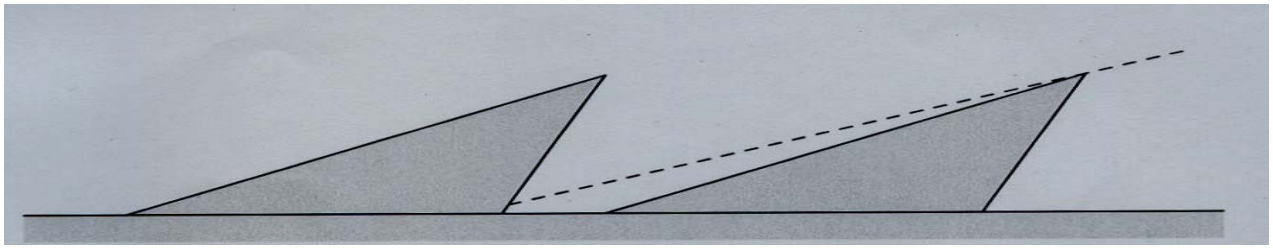
n	Int (bn) (g-cm)	Int (bn)/(b1) (ratio)	Int (an) (g-cm)	Int (an)/(b1) (ratio)
1	4.99742e+05	1.00000e+00	0.00000	0.00000
2	-1.35119e+02	-2.70378e-04	6.40919e+00	1.28250e-05
3	-9.05941e+01	-1.81282e-04	-5.27759e+00	-1.05606e-05
4	7.11133e+01	1.42300e-04	-2.35036e+00	-4.70315e-06
5	8.88407e+01	1.77773e-04	-2.05767e-01	-4.11747e-07
6	8.62674e+00	1.72624e-05	4.75541e+00	9.51574e-06

ELECTRON PATH





ELECTRON CATCHER



LECTRONS ARE SPIRALING WITH ~20^{O} PITCH AT THE BOTTOM OF THE VACUUM CHAMBER

HE CATCHER HAS UNDER CUT IN ORDER NOT TO RELEASE ANY SECONDARY ELECTRONS

PHASE SPACE PAINTING

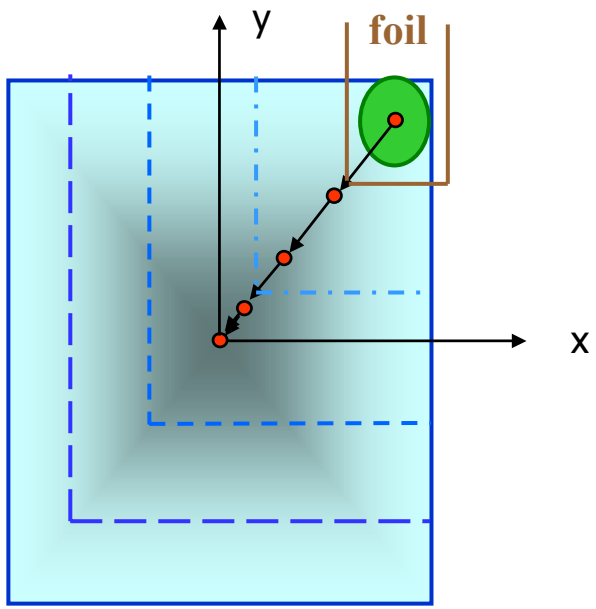
- CREATE DESIRED PHASE SPACE DISTRIBUTION FROM LINAC BEAM
  - TO CONTROL LOSS DUE TO SPACE CHARGE
  - REDUCE FOIL HITS BY CIRCULATING BEAM
  - TO SATISFY DISTRIBUTION AT THE TARGET

LINAC TO RING INTERFACE PARAMETER

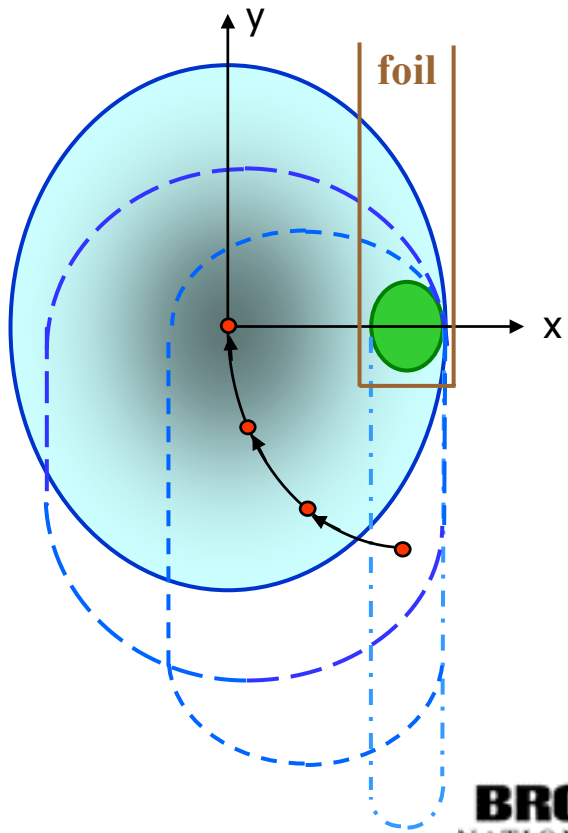
Trans. Emitt.	< 0.5 pi mm mr (norm, rms)
Energy spread	±0.3 MeV (rms)
Bunch spread	±1.5 deg (rms)
Energy centroid error	± 1.5 MeV max
Phase centroid error	± 2 degrees
Beam halo outside 5 sigma	$<10^{-4}$
Beam chopper gap	$< 10^{-4}$

BASIC PAINTING SCHEMES

Correlated painting

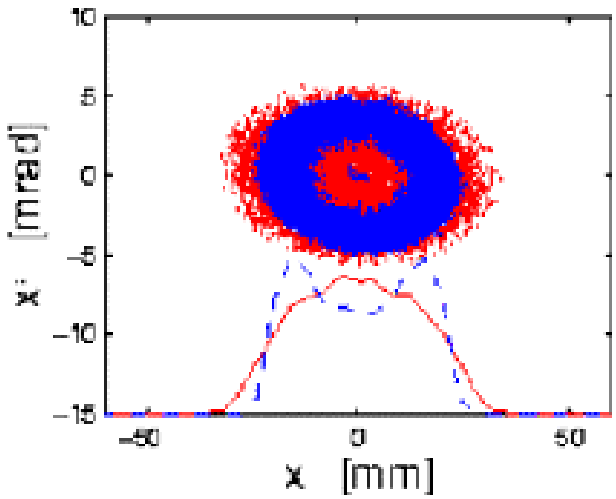


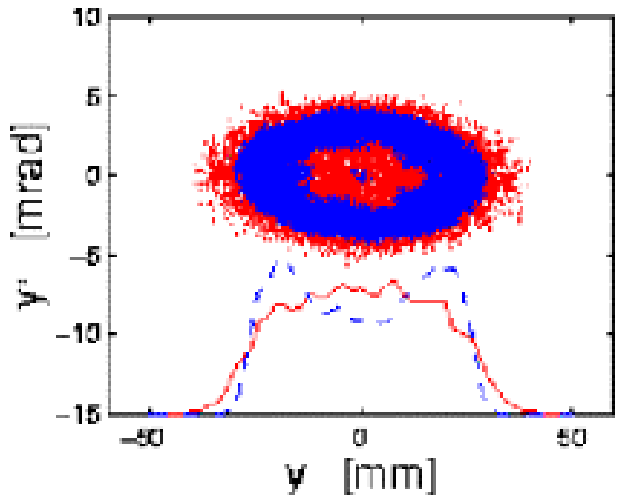
Anti-correlated painting

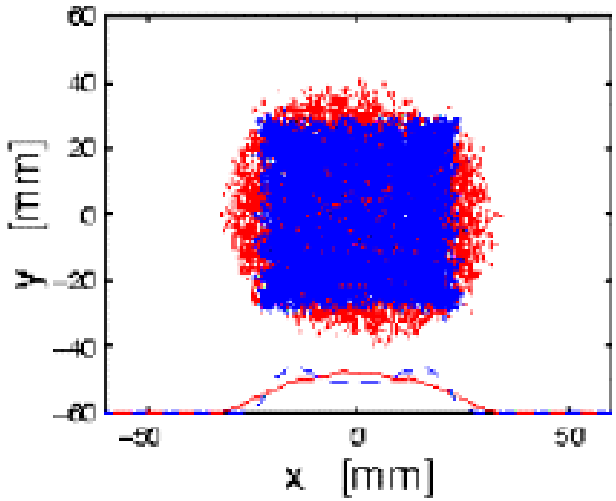


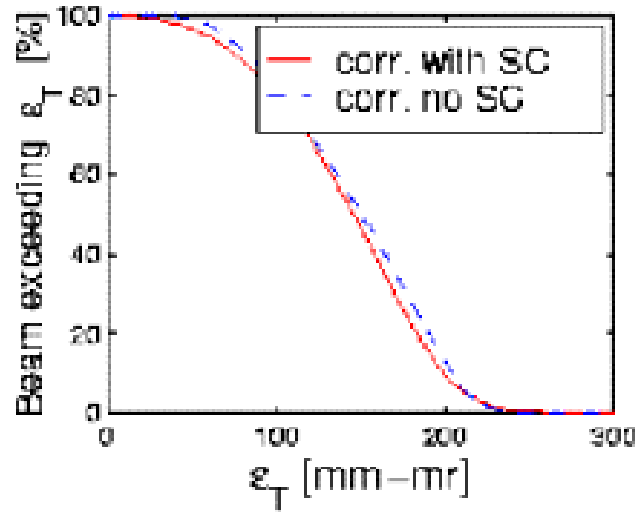
CORRELATED PAINTING

Correlated painting with/without space charge









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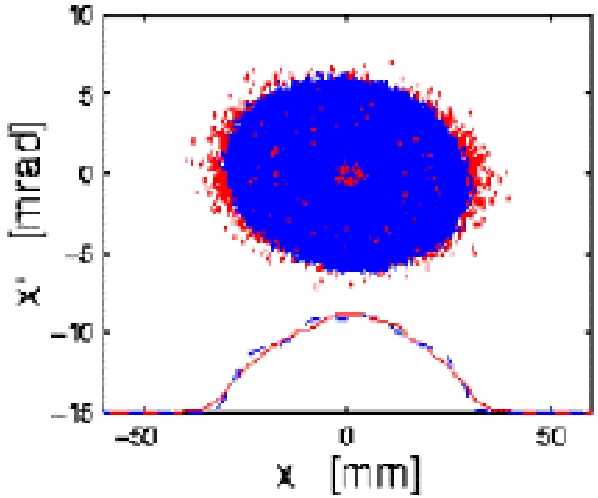
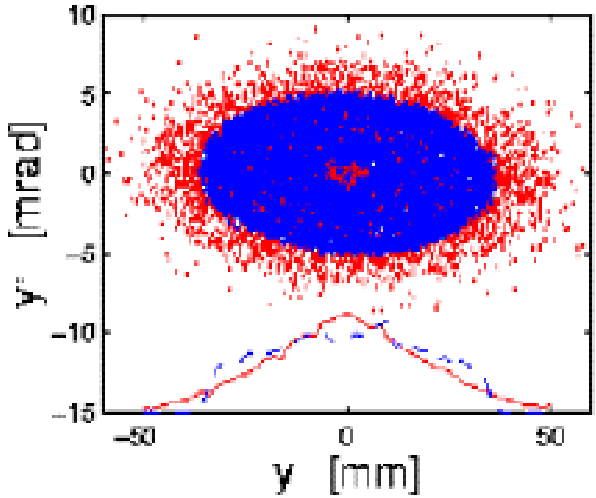
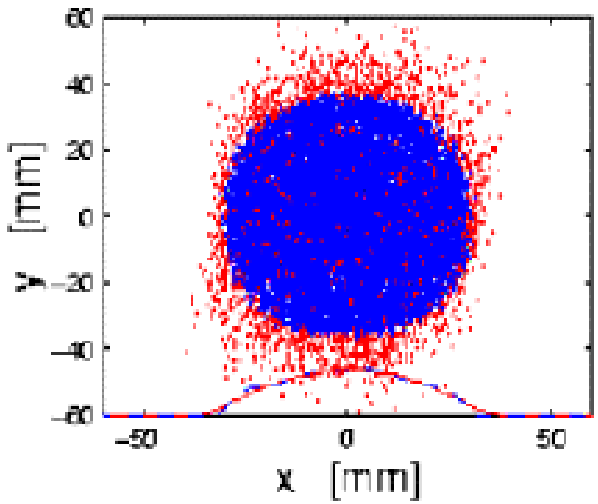
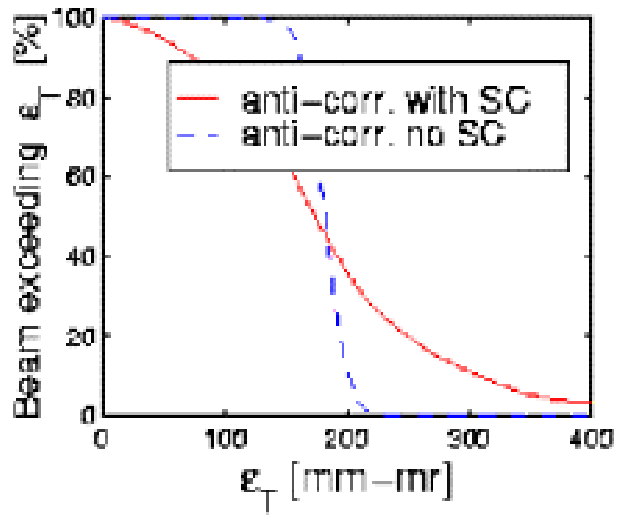
ANTI-CORRELATED PAINTING

Anti-correlated painting with/without space charge



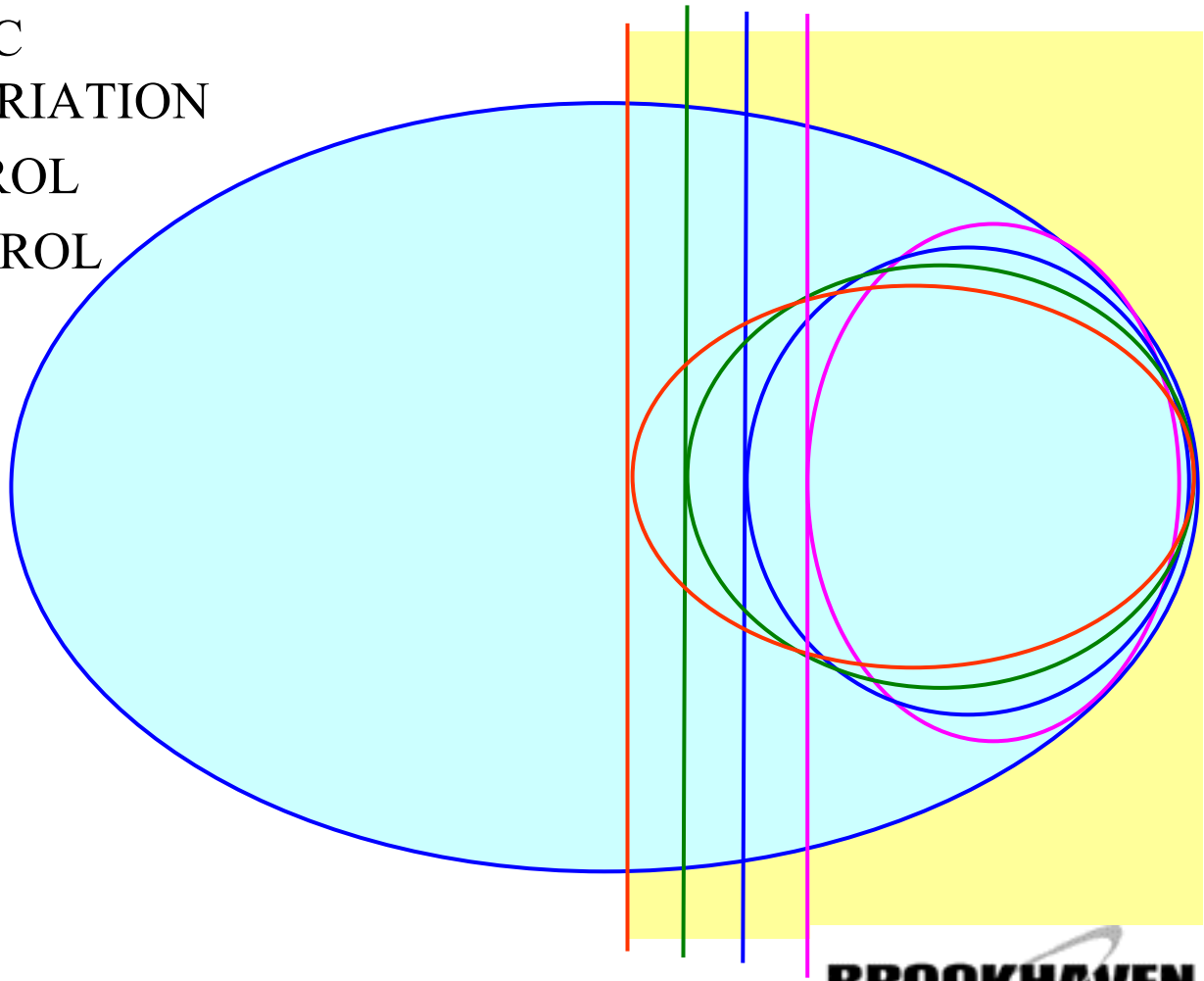






INJECTION MISMATCH AND FOIL LIFE

- USE INJECTION MISMATCH TO
  - COUNTER LINAC EMITTANCE VARIATION
  - FOIL HIT CONTROL
  - FOIL LIFE CONTROL



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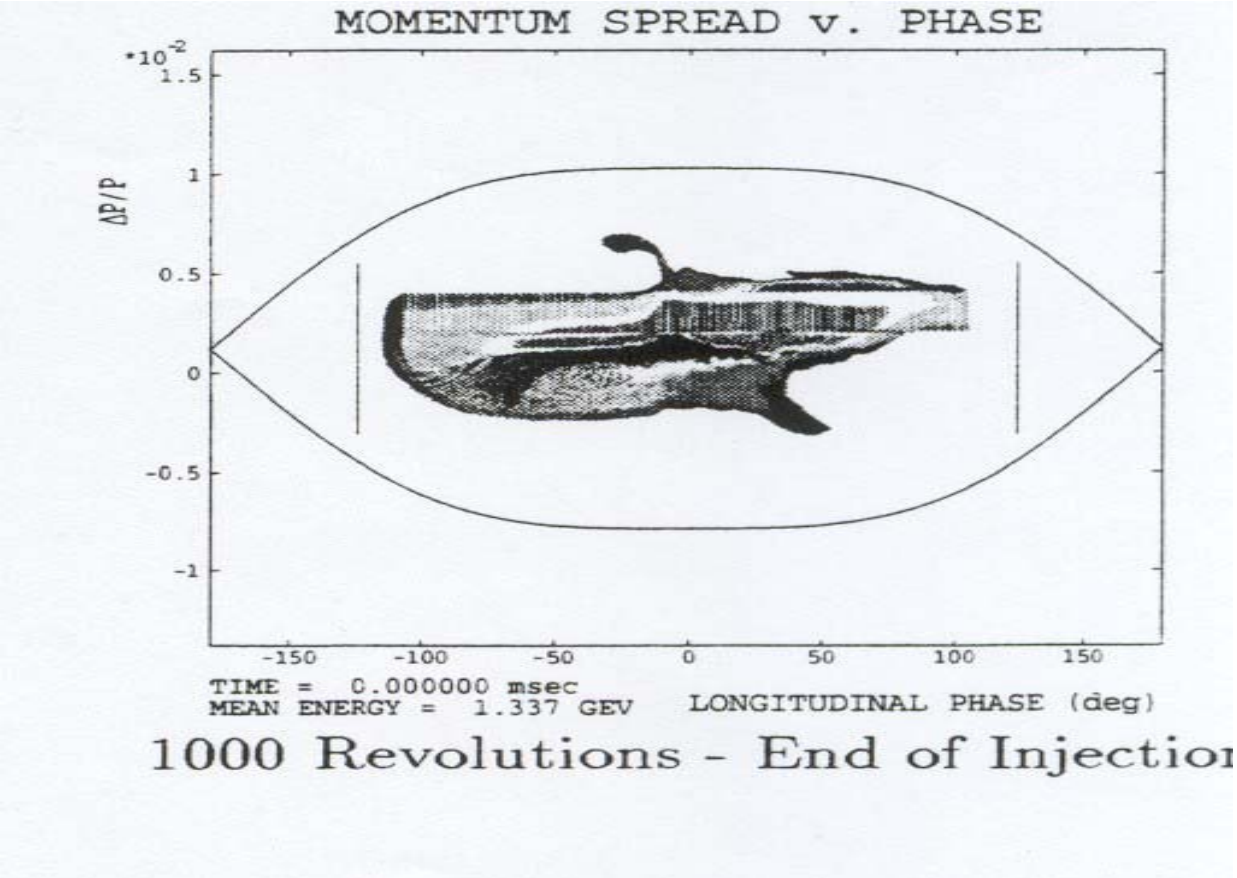
LONGITUDINAL PHASE SPACE PAINTING

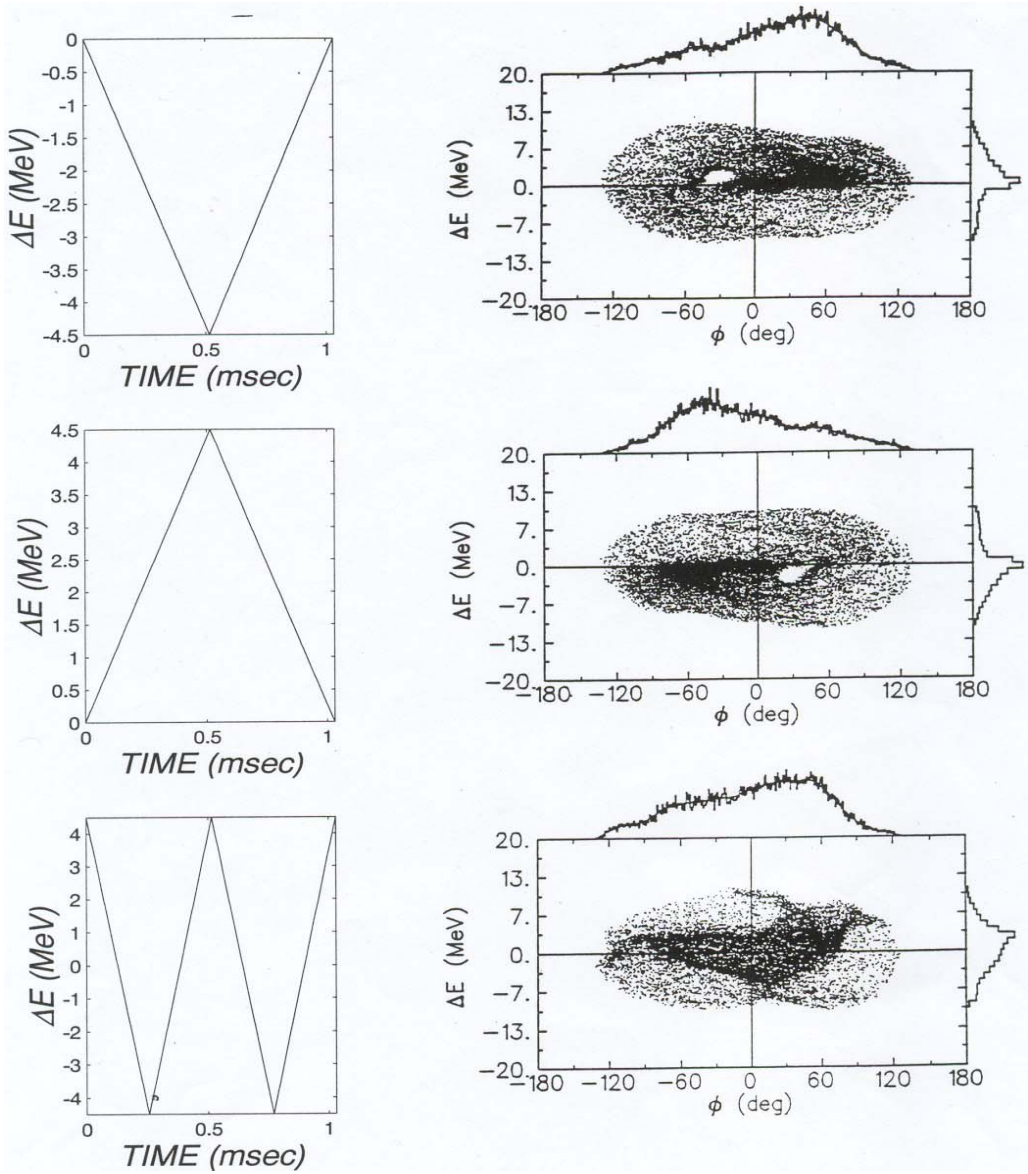
- PLANED BUT NOT IMPLEMENTED
- KEEP EXTRACTION GAP CLEAN
  - MEBT CHOPPER
- REDUCE SPACE CHARGE EFFECT
- TO HAVE HANDLE ON LONGITUDINAL AND TRANSVERSE INSTABILITIES
  - USE ENERGY SPREADER TO CONTROL THE ENERGY SPREAD WITHOUT ENERGY TAIL
- INJECTING IN DISPERSION FREE STRAIGHT GIVES FREEDOM TO CHOOSE ENERGY SPREAD

LONGTUDINAL DISTRIBUTION ESS

- ESS LONGITUDINAL DISTRIBUTION AFTER 1000 TURN INJECTION

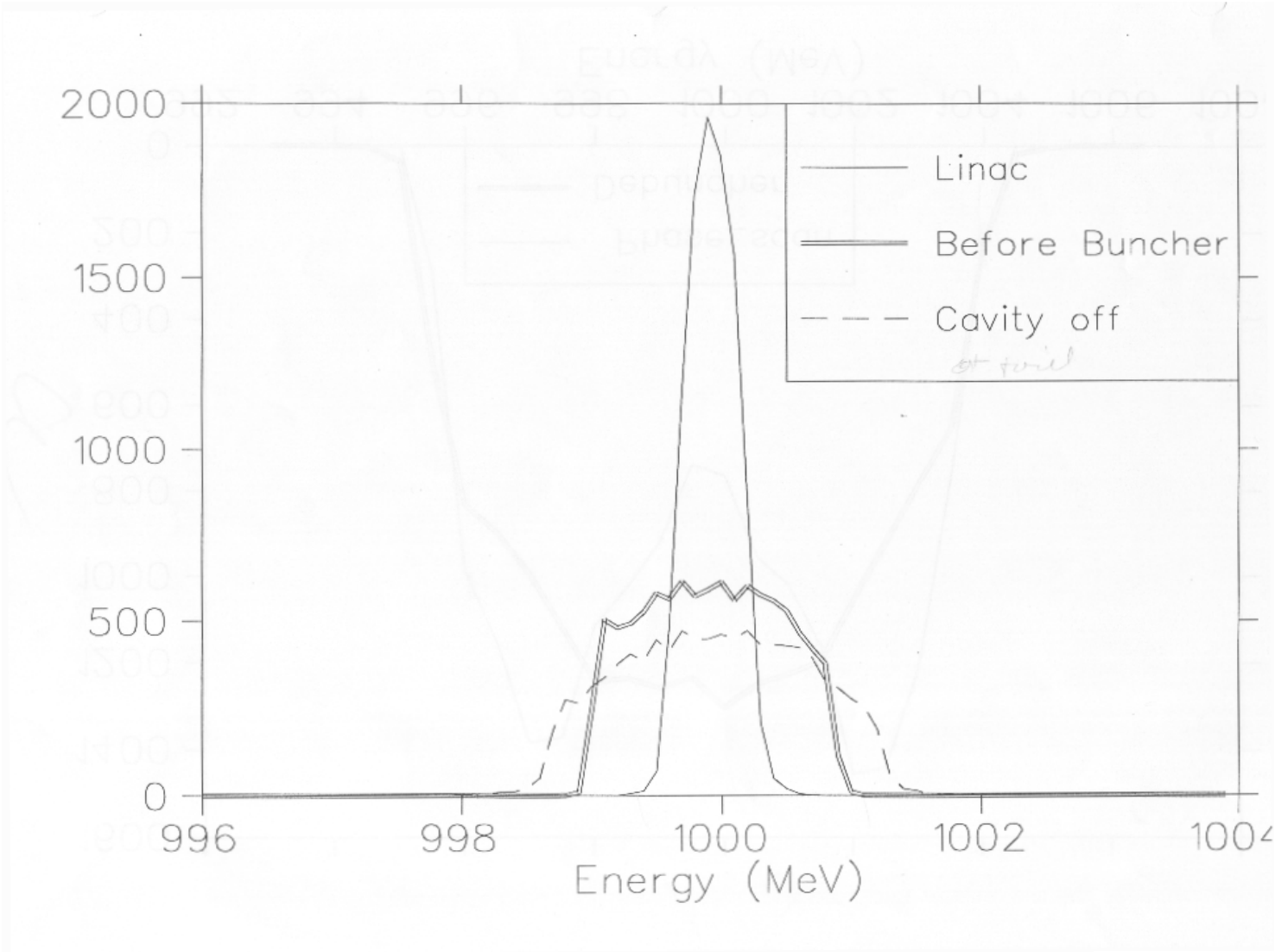


INJECTION WITH LINAC PHASE RAMPING

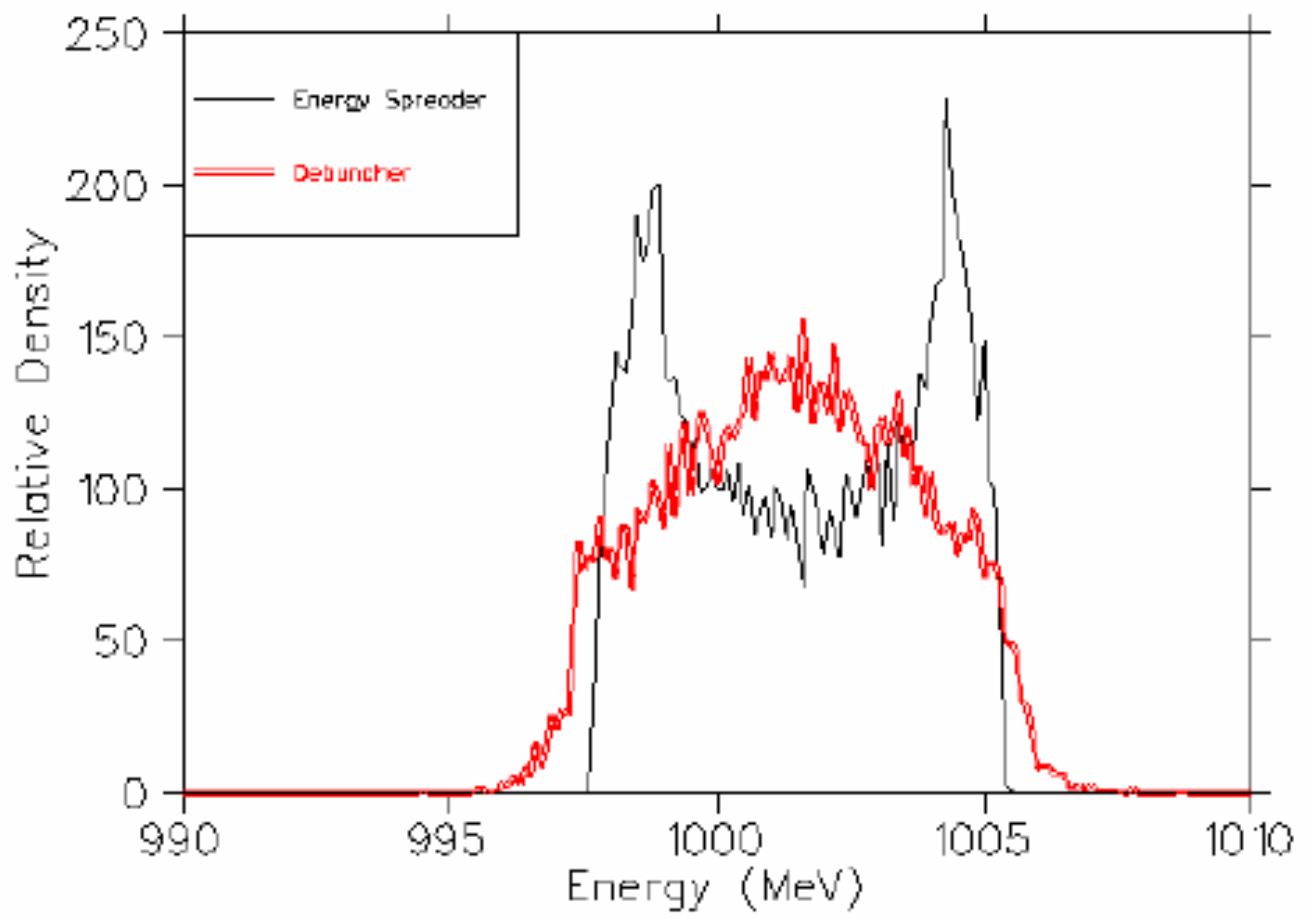


- ENERGY VARYING INJECTION LEAVES LUMPINESS IN LONGITUDINAL DISTRIBUTION

EXPECTED ENERGY SPREAD IN HEBT



ENERGY SPREAD BY PHASE SCAN



LONGITUDINAL DISTRIBUTION WITH SPREADER

- ENERGY SPREADER CAVITY 3.5 MV
- Δf =100KHz